Granular Materials Image Analysis

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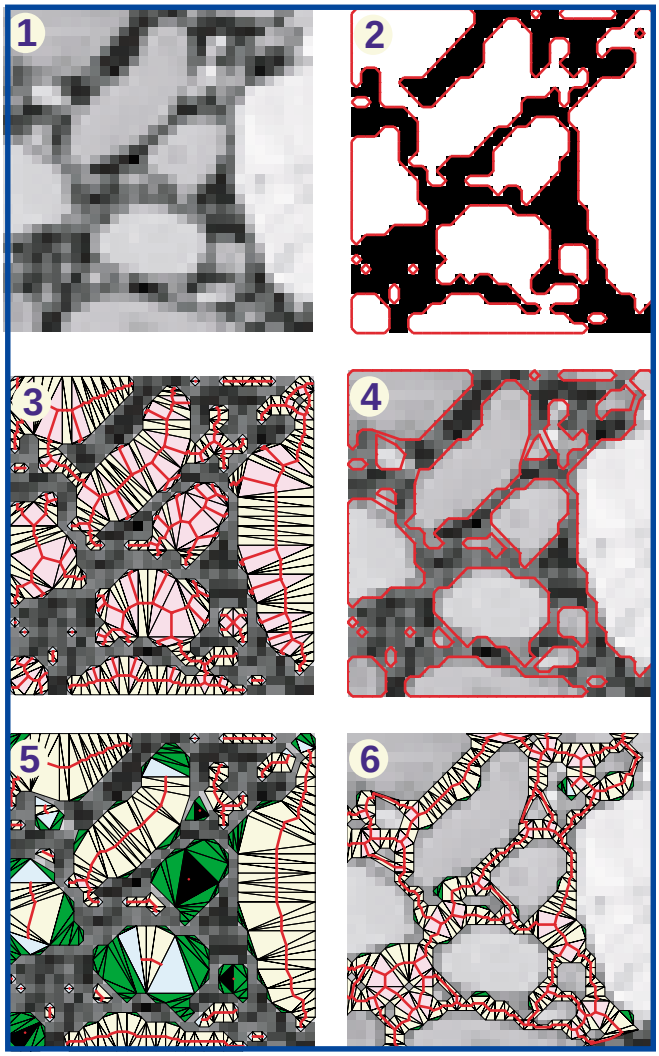
A new technique [1, 2] for the morphological analysis of shapes is applied to micrographs, i.e., grey-scale images (Figure 1), of granular materials for the first time. The purpose of this effort is to provide material statistics, e.g., distributions of grain sizes, aspect ratios, and orientations, respectively, as very accurate initial conditions to hydrodynamic model calculations, which are being performed in the field of micromechanics of mater-ials to investigate the propagation of shock-waves through these media.



In the following, we demonstrate how to acquire the shape feature data from a micrograph of a granular material as shown in Figure 1, by using low- and high-level image processing algorithms. First we perform a segmentation of the image by applying either pulse-coupled neural networks [3], or a wavelet based spectral segmentation. This leads to the black and white areas in Figure 2. Then we extract the contours (red lines in Figure 2) of the segmented blobs with a newly developed algorithm [4], which is highly parallel.

The contours and its points form the input to the Chordal Axis Transform [1, 2] (CAT), which provides a morphological decomposition of grain shapes into simplicial chain complexes of limbs and torsos (Figure 3). This decomposition is used to perform grain separation based on a Monte Carlo sampling of grey-scale morphology, which leads to a refinement of the earlier computed contours (Figure 4). Using the newly found contours and its points, the CAT is applied again to both the grain regions and the binder regions, respectively.

Pruning of morphol-ogically-insignificant shape features leads to the final attributed skeletons for the grains (Figure 5) and the binder material (Figure 6), where each connected arc of a skeleton is regarded as the axis of a particle (green triangles in Figures 5 and 6 are associated with a particle's shape features).

Subsequent to such filtering, the metrical and statistical properties of the granular material are efficiently computed to obtain the input for the hydrodynamic model calculations.

In summary, our algorithms transform the spectral pixel information of a micrograph into an affine geometric description, which allows us to analyse the morphology of granular materials.

[1] L. Prasad, “Morphological Analysis of Shapes,” *CNLS Newsletter*, No. 139, July ‘97, LALP-97-010-139, Center for Nonlinear Studies, Los Alamos National Laboratory.

[2] L. Prasad, R. Rao, “Morphological Analysis of Shapes,” in *Special Feature, Theoretical Division Supplement to Self-Assessment 97/98*, Los Alamos, May 1998, LA-UR-98-1150, p. 107.

[3] A. N. Skourikhine, “Parallel Image Processing with Autowaves: Segmentation and Edge Extraction,” Los Alamos Preprint, LA-UR-00-422.

[4] B. R. Schlei, L. Prasad, “A Parallel Algorithm for Dilated Contour Extraction from Bilevel Images,” Los Alamos Preprint, LA-UR-00-309, cs.CV/0001024.

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